TEACHING MATHEMATICS AND LANGUAGE TO ENGLISH LEARNERS

CALUIAN/THINKSTOCK

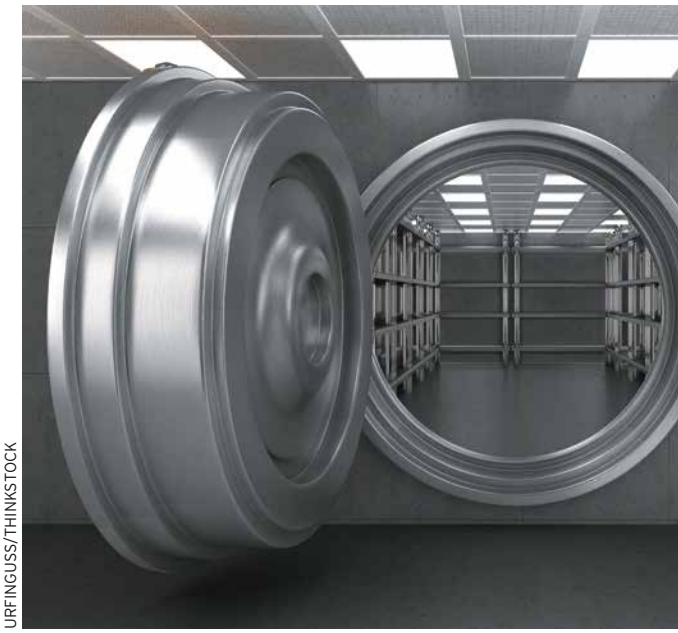
Five questions to guide an approach for effectively embracing the teacher's dual role.

Chad Leith, Elena Rose, and Tony King

To create a classroom learning community in which all students are engaged and inspired, a mathematics teacher's mastery of the content must be matched by an awareness of the needs of individual students and an understanding of the instructional strategies that will enable all learners to develop their mathematical knowledge and skills.

Yet when the classroom includes English learners (ELs), students from immigrant families who are not yet fully proficient in academic English, establishing such a learning community requires a mathematics teacher to look beyond the strategies that have worked well with fluent English speakers. To achieve success in the mathematics classroom, EL students must learn both mathematics and English simultaneously. This means that a teacher who has EL students in his or her classroom is not only a mathematics teacher but also a language teacher.

Consciously working to boost students' academic language proficiency can pose a challenge if teachers are more accustomed to thinking about mathematical content than their students' language needs. The pressures of shifting state standards and federally mandated high-stakes assessments can also make the notion of setting aside time for language development feel overwhelming. However, we believe that creating a classroom community that is welcoming to students from linguistically diverse backgrounds requires deliberately promoting both content knowledge and language development.



URFINGUSS/THINKSTOCK

FIVE QUESTIONS

Teachers who have effectively embraced the dual role of mathematics and language teacher are guided by the considerations below. We present

FOOT

IMAGE SOURCE PINK/THINKSTOCK

KERMITGRN/THINKSTOCK

HORSE

ALEXIA_KHRUSHCHEVA/THINKSTOCK

BANK

PHOTOS.COM/THINKSTOCK

TRAIN AT LANDSCAPE

VAULT

MARKO RUPENA/THINKSTOCK

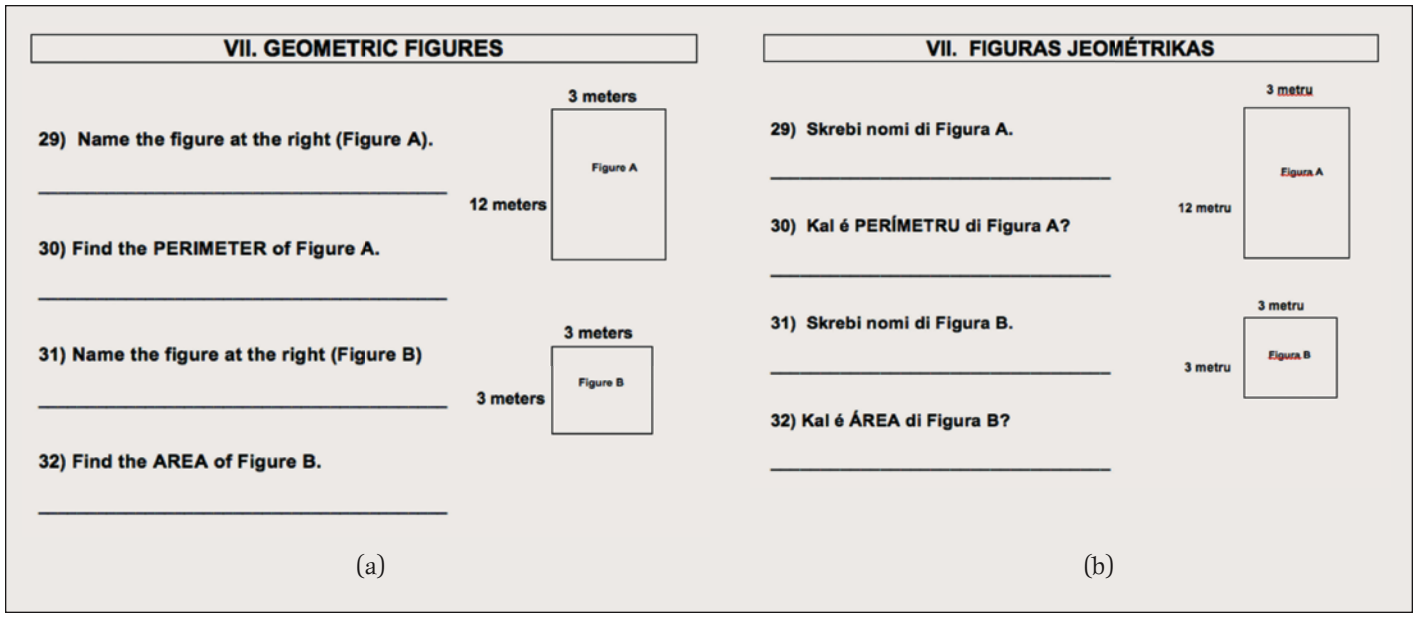


Fig. 1 High school mathematics intake assessments are shown in English (**a**) and Creole (**b**).

them as five questions that you might ask yourself as you approach your own work with EL students.

Why Are My EL Students Considered "English Learners"?

Whether your English learners were born in Mexico, China, Haiti—or the United States—and whether they first learned to speak in Farsi, French, or Spanish, they have been identified as EL students because they have not yet demonstrated a level of academic English proficiency comparable to that of their English-proficient peers. Under federal law, states and public school districts are required to assess and monitor EL students' levels of English proficiency each year. Connecting with the person in your school or district who has access to data on the proficiency levels of EL students can be extremely helpful for gaining an understanding of the current language abilities of your students.

Another helpful resource, the WIDA CAN DO Descriptors (http://www.wida.us/standards/CAN_DOs/), represents a concise and practical set of grade-specific documents that articulate what EL students "can do" at different levels of English language development. These descriptors, used by schools and districts in thirty-six states, identify EL students as being somewhere along a six-level continuum of language proficiency. Those at level 1 are the least proficient in English, and those at level 6 are those who have achieved a level of proficiency that approximates that of non-ELs of the same age. It is not uncommon for EL students to be placed in regular general education (i.e., "mainstream") classrooms before they have made their way through this process. As a teacher of ELs, you must know how far along your students have progressed so that you can effectively address the potential gaps that exist between their language abilities and the linguistic demands of your classroom activities and tasks.

What Mathematics Do My English Learners Already Know?

In addition to knowing how much English your ELs have acquired, it is also important to know how much mathematical knowledge they bring to your classroom. Just because your English learners are still learning English does not mean that they are necessarily behind in their understanding of mathematical concepts. Assessing what students already know will help you target areas where your ELs may need catching up as well as areas of knowledge that you can build on.

To assess the mathematical knowledge of new arrivals, some public school districts ask them to take a short mathematics assessment that is pre-translated into multiple different languages. Such assessments often include topics ranging from basic operations to algebraic expressions and geometric principles. Because the answers to the assessment items are the same regardless of the student's native language, the mathematics teacher need not speak the student's language to gain valuable insights about the student's mathematical background knowledge. For students with limited or interrupted formal schooling, such an assessment may reveal significant gaps that will need to be addressed for them to be successful in your classroom. **Figures 1a** and **1b** offer an excerpt of what this type of preassessment might look like in a school or district serving EL students from Cabo Verde.

In addition to learning about your students' mathematical background knowledge, it is also helpful to keep in mind that mathematics looks different in other parts of the world. In Cabo Verde, for example, as in countries such as Brazil and Portugal, the steps for showing long division look like an upside-down version of the procedure commonly taught to U.S. schoolchildren. Further, decimal fractions are expressed with a comma (6,82) instead of a point (6.82). Thus, an EL student from Cabo Verde might solve the equation 2,562 ÷ 5 with an approach like the one shown in **figure 2**.

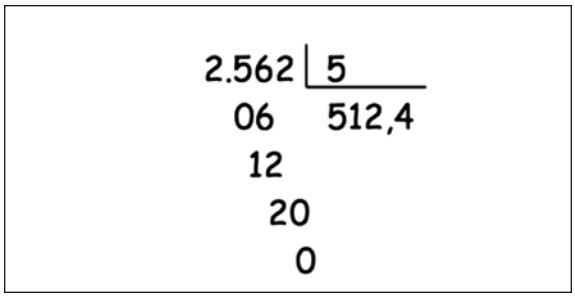


Fig. 2 An example of long division in Cabo Verde appears different from calculations typically completed in the United States.

Identifying and understanding the nuances of mathematics in the home countries of your ELs can help you understand your students' reasoning and anticipate areas of confusion. It can also serve to communicate to ELs and their families that you have an "asset-based" (rather than a "deficit-based") view of the knowledge that they bring from their home countries.

How Can I Make My Lessons More Accessible to EL Students (Without Simplifying Mathematical Content)?

Once you have developed an understanding of your students' strengths in English and mathematics, the next step is to think carefully about the linguistic demands of the tasks that you ask your students to complete in class. Consider this example involving the Common Core Standards for high school algebra, which require that students "perform arithmetic operations on polynomials" (HSA.APR.A.1, CCSSI 2010). Imagine that you are facilitating a lesson on factoring trinomials and are using an algebra textbook that provides students with the following model for the vertical motion of a projected object: $h = 16t^2 + vt + s$, "where h is the height in feet, t is the time in seconds, v is the initial upward velocity in feet per second, and s is the starting height of the object in feet" (Holliday and Cuevas 2003, p. 498). To encourage students to practice applying this formula, the textbook also provides the following word problem in its "Application" section:

> When a gymnast making a vault leaves the horse, her feet are 8 feet above the ground traveling with an initial upward velocity of 8 feet per second. Use the model for vertical motion to find the time t in seconds it takes for the gymnast's feet to reach the mat. (Holliday and Cuevas 2003, p. 499)

Although this problem is designed to provide a context through which students can apply the formula, it contains many linguistic pitfalls, which might interfere with your EL students' understanding (and, in turn, their performance). In an article on the assessment of EL students in mainstream classrooms, Lenski et al. (2006) point out that "a text that is not comprehensible will only measure the vocabulary that a student does not know" (p. 31). Applied to the problem above, this statement means that if students are unable to understand the language of the problem, they will be unable to demonstrate their understanding of the mathematics. For teachers of EL students, a first step toward reducing linguistic interference in your classroom is to analyze the language requirements of the texts and tasks that you present to your learners.

In the case of the gymnastics problem, it is important to, first, acknowledge that the context itself may be unfamiliar to some EL students. In his excellent work on reading in the academic disciplines, Buehl (2011) points to the critical importance of background knowledge and visualization for understanding content-area texts. We cannot take it as a given that learners from all parts of the world have seen a "gymnast making a vault." A learner who does not understand that "making a vault" means to propel oneself into the air will not be able to correctly apply the formula for this problem.

In fact, the word *make* here might stimulate mental images of a person creating something (as in *making a cake*). Other potentially confusing features of the gymnastics problem include its many polysemous words (words with more than one meaning), such as *vault*, *feet*, and *horse* (which ELs most closely associate with an animal rather than a piece of gymnastics equipment). In its lengthy opening sentence, the problem also uses two different meanings of the word *feet* ("her *feet* are 8 *feet* above the ground. . . ."). In addition, the problem uses two different words, *ground* and *mat*, to refer

Make the context of the problem familiar to a much broader range of learners.

to the same thing. This is a lot of unnecessary linguistic interference if your goal is to determine whether or not your EL students can correctly apply the formula and solve the equation.

After you have analyzed the linguistic demands of the task, your next step, of course, is to decide what to do about it. Keeping the problem as it is will require, at a minimum, addressing potential knowledge gaps. A labeled picture of a gymnast making a vault, for example, with key words like "horse" and "mat" labeled in the image would help supply some background knowledge that your non-ELs might bring to the problem. The use of visual scaffolds to build background and the consideration of EL students' prior knowledge are hallmarks of the Sheltered Instruction Observation Protocol (SIOP) model (Echevarria, Vogt, and Short 2012), a popular resource that provides a range of additional helpful suggestions for making grade-level content accessible to ELs.

If you have decided to keep the problem as it is, another way to support EL students is by making them aware of *cognates*, words that are similar across languages. For students from Latinate language backgrounds, such as Spanish, French, and Portuguese, many key mathematical words are highly similar: *Velocity* in Spanish is *velocidad*; *initial* in Portuguese is *inicial*. Other cognates in the gymnastics problem include *motion* and *vertical*. Awareness of such cognates fosters student independence, because ELs are able to draw on words and concepts that they already know to make meaning of English-language texts. To foster cognate awareness, some teachers create cognate charts, where new cognates as they appear in classroom texts and activities are recorded in both English and the languages spoken by their ELs. With online translation tools, it is possible to identify cognates and key vocabulary words for your students even if you are not proficient in their native languages.

Awareness of cognates can foster independence, but it is also important to explicitly teach the key mathematical terms that EL students will need to fully participate in class activities (Francis et al. 2006). Words like *height*, *project*, and *upward* are "must-learn" vocabulary words that could be explicitly taught before students tackle this problem.

Although the supports described here would help reduce the linguistic interference of the gymnast problem, another option you have when helping make word problems more accessible to your EL students is to rewrite them altogether (Carr et al. 2009). Consider the following, more EL-friendly version of the gymnastics problem, which assesses the same mathematical skills as the original:

> Maria is a goalkeeper on a soccer team. During a soccer game, Maria kicks the soccer ball to the opposite side the field. The ball is 1 meter above the ground when Maria kicks it. When she kicks it, the ball has an initial upward velocity of 8 meters per second. Use the model for vertical motion to find the time t in seconds it takes for the ball to land on the ground at the opposite side of the field after Maria kicks it.

Note the additional supports and modifications that have been added to this rewritten problem. In their work on teaching EL students with interrupted schooling in U.S. secondary schools, DeCapua and Marshall (2011) emphasize the value of cultural relevance and conceptual familiarity in helping students acquire content understanding. To this end, the substitution of soccer for gymnastics makes the context of the problem familiar to a much broader range of learners. The inclusion of a proper noun (Maria) also signals that there is a person doing something in the word problem. Further, *feet* have been changed to *meters*, a more universally recognized unit of measurement. Finally, the lengthy sentences from the first problem have also been reduced to simpler and more straightforward syntax. Each of these changes helps chip away at the potential linguistic barriers that stand in the way of your EL students' full participation in this lesson.

We recognize the importance of exposing our EL students to the types of decontextualized and linguistically complex word problems that they are likely to encounter when taking high-stakes standardized assessments. However, we must also keep in mind that learning a new language is a process. Although we certainly want to gradually increase the linguistic complexity of the tasks and texts that we present to our ELs, we also want to ensure that they are able to practice and demonstrate their

NCTM® NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

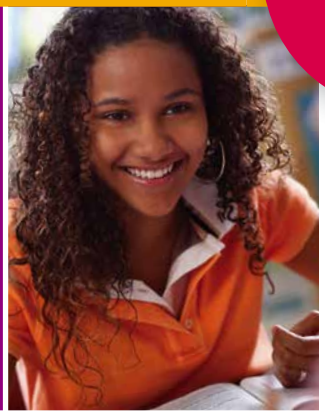
PREMIER MATH EDUCATION EVENTS

Register by MAY 22 and save $40!

Atlanta | July 14–16, 2016

Engaging Students *in* Learning: Mathematical Practices

AN NCTM INTERACTIVE INSTITUTE FOR GRADES 9–12



Engage Your Students in Learning

As a teacher, supervisor, or math coach of high school mathematics, you need the best strategies to prepare your students for success. At NCTM's Interactive Institute *Engaging Students in Learning Mathematical Practices for High School Teachers*, you will receive hands-on learning tailored for specific areas of focus.

- **Address the most pressing issues** facing high school mathematics education during keynote presentations from innovators in the field.
- **Collaborate and share ideas, strategies, and solutions** during topic-specific breakout sessions
- **Enhance your understanding** of how to effectively address the eight Mathematics Teaching Practices from *Principles to Actions*, college- and career-ready standards, the common core mathematical practices, and more.

Learn more at nctm.org/institutes and follow us on #NCTMinstitutes

Use the classroom space to maximize student learning and facilitate student independence.

understanding of grade-level mathematics concepts along the way.

How Can I Incorporate Meaningful Language Practice into My Lessons?

In addition to analyzing the language demands of a particular mathematics lesson, it is also important to include in your lessons multiple and varied opportunities for EL students to practice using English in class. We have all had experiences learning (or attempting to learn) a second language. Whether it was a Spanish class in middle school or a summer exchange program in France, you may recall that opportunities to practice the language in meaningful ways (or a lack of such opportunities) probably had an effect on how well you learned the language. The same is true for English learners. The more opportunities that EL students have to speak and write about mathematics in English, the more quickly they will develop their academic English proficiency overall (Peregoy and Boyle 2013).

Incorporating short writing activities in the classroom is one way to boost language practice opportunities. Having your students explain their steps in complete written sentences using sequencing words (such as *first*, *next*, *then*, *finally*) can help reinforce vocabulary and content understanding while also providing EL students with a chance to do some thinking about a particular problem before discussing it aloud in class.

Mathematics teachers who effectively address the language needs of their EL students also look for opportunities to get their students talking—in pairs, in small groups, and in front of the class. For example, instead of standing at the front of the room and prompting the whole group to supply you with next steps for solving a problem (e.g., "OK, what do I do next?"), a teacher might instead hand over the SMART Board™ marker and put the students in charge of walking through the procedure. Of course, preparing ELs to participate in this way may require letting them first complete and discuss the problem with a partner. But "yielding the floor" can open valuable space for students to practice their language skills in the mathematics classroom.

Designing tasks that are worth talking about is also essential for promoting meaningful classroom interactions. Rather than asking students to "calculate the total payment of a $15,000 car with 5-year loan at a 7 percent annual rate of interest," for example, you might ask pairs of students to decide whether they would prefer to purchase a car at a 7 percent rate over 3 years or a 5 percent rate over 6 years. By asking students to discuss their predictions, complete their calculations, and then explain their choices to others, you will add an important language practice step to the sequence of your lesson.

Learning mathematics and learning a language both require risk taking, so it is important that these efforts to support and develop language occur within the context of a supportive and welcoming classroom community. EL students must feel comfortable to be able to test out their new mathematical knowledge and new English skills. They should be encouraged to participate in this mathematical discourse by asking questions, providing answers, discussing logical reasoning, and citing mathematical evidence—both orally and in writing. Adding even one language development activity each day can help your EL students make strides toward mastering the language of mathematics.

How Can I Leverage My Classroom Space to Enhance Student Learning?

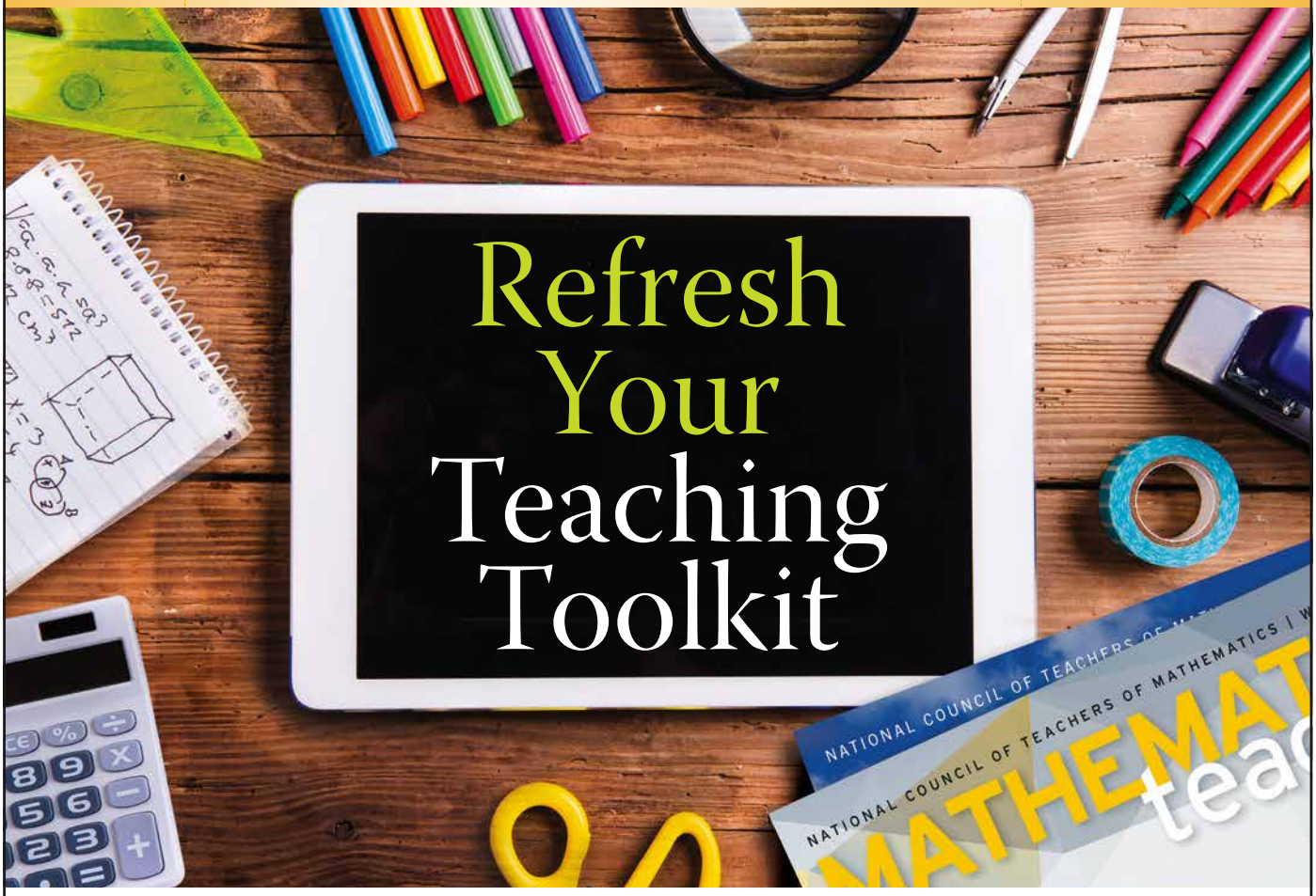
Finally, the physical space of your classroom can play an important role in language and literacy development. Effective mathematics teachers support their ELs' language development by using the classroom space to maximize student learning and facilitate student independence. Word walls, anchor charts, and other visual aids, while ubiquitous at the elementary school level, appear all too infrequently in high school classrooms.

In writing about teaching and learning in mathematics, Calderón (2007) suggests that in addition to promoting cognate awareness (discussed previously in this article), mathematics teachers should also foster an awareness of the different ways in which we refer to similar operations in English. For instance, an EL student may be familiar with the words *subtract* and *subtraction* but may not be aware of the connections between these words and expressions such as *minus*, *difference*, *less than*, and *take away*. Creating word walls for different mathematical operations and adding to them as new words are encountered can help EL students build important vocabulary knowledge.

Having a word wall and visuals updated to reflect current units of study (e.g., the slope formula for a unit on linear equations) can help students quickly recall important concepts and language when completing classroom activities. Anchor charts with guidance on the use of math-

NCTM® NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

INSPIRING TEACHERS. ENGAGING STUDENTS. BUILDING THE FUTURE.



Looking for a new way to approach challenging topics? Is it time to update your tried-and-true classroom activities? As an NCTM member, hundreds of research-based, peer-reviewed, and grade-band specific mathematics education resources are at your fingertips.

Find the tools you need and collaborate with your peers when you take full advantage of your NCTM connection.

Member-Only Resources *visit nctm.org*	**NCTM Publications** *shop nctm.org/store*	**NCTM Events & Conferences** *see all events at nctm.org/conferences*
■ Lesson plans	■ Professional development resources	■ Collaborative knowledge and resource sharing
■ Student activities	■ Mathematics education research insights and applications	■ Focused professional development
■ Assessment tools	■ Classroom activities and strategies	■ Practical applications of strategies and tools

ematical expressions or sequencing words can occupy prominent space as well. Students can create these charts and posters. This creation stage is an engaging and worthwhile learning opportunity for students. Also, many standardized assessments allow formula sheets or other supports. These tools should be posted in the classroom so that students become confident users of the additional supports before relying on them in a testing environment.

COLLABORATE TO REACH OUT

Mathematics is not just about numbers, variables, statistics, probability, and geometric figures. It is also about problem solving and logical reasoning. Mathematics is a discourse that is both oral and written—and language is a basic prerequisite for meaningful participation in classroom learning communities. English learners represent the fastest-growing segment of the K–12 student population in the United States. We believe that embracing the dual responsibilities of teaching both mathematics and the language of mathematics represents an exciting area of professional growth and an opportunity to welcome culturally and linguistically diverse learners into our classrooms.

To begin the process of analyzing and modifying the language dimension of your mathematics classroom, you might consider collaborating with another teacher at your school who has experience working with English learners. Such collaboration between general education teachers and ESL instructors is a characteristic of schools that effectively serve EL students. If your school has no staff members with EL expertise, consider reaching out to district-level personnel, regional education service centers, state education agencies, or nearby college or university faculty members.

Once you become comfortable with the process of planning for both content and language, your lessons will have a powerful impact on both the mathematics learning and the language development of your ELs. This process will also empower your ELs to participate more comfortably and confidently as members of your classroom learning community.

REFERENCES

Buehl, Doug. 2011. *Developing Readers in the Academic Disciplines.* Newark, DE: International Reading Association.

Calderón, Margarita. 2007. *Teaching Reading and Comprehension to English Learners, Grades 6–12*. Thousand Oaks, CA: Corwin Press.

Carr, John, Cathy Carroll, Sarah Cremer, Mardi Gale, Rachel Lagunoff, and Ursulu Sexton. 2009. *Making Mathematics Accessible to English Learners, Grades 6–12: A Guidebook for Teachers*. San Francisco: WestEd.

Common Core State Standards Initiative (CCSSI). 2010. Common Core State Standards for Mathematics. Washington, DC: National Governors Association Center for Best Practices and the Council of Chief State School Officers. http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

DeCapua, Andrea, and Helaine W. Marshall. 2011. *Breaking New Ground: Teaching Students with Limited or Interrupted Formal Education in U.S. Secondary Schools*. Ann Arbor: University of Michigan Press.

Echevarria, Jane, MaryEllen Vogt, and Deborah Short. 2012. *Making Content Comprehensible for English Learners: The SIOP Model.* 4th ed. Boston: Allyn and Bacon.

Francis, David, Mabel Rivera, Nonie Lesaux, Michael Kieffer, and Hector Rivera. 2006. *Practical Guidelines for English Language Learners: Research-Based Recommendations for Instruction and Academic Interventions.* Portsmouth, NH: RMC Research Corporation, Center on Instruction. http://www.centeroninstruction.org/files/ELL1%2DInterventions%2Epdf

Holliday, Berchie, and Gilbert Cuevas. 2003. *Algebra 1*. New York: Glencoe/McGraw-Hill.

Lenski, Susan Davis, Fabiola Ehlers-Zavala, Mayra C. Daniel, and Xiaoqin Sun-Irminger. 2006. "Assessing English Language Learners in Mainstream Classrooms." *The Reading Teacher* 60: 24–34.

Peregoy, Suzanne F., and Owen F. Boyle. 2013. *Reading, Writing, and Learning in ESL: A Resource Book for Teaching K–12 English Learners*. Boston: Pearson.

WIDA Consortium. 2009. *The English Language Learner CAN DO booklet.* Board of Regents of the University of Wisconsin System. http://www.wida.us/standards/CAN_DOs/

CHAD LEITH, cleith@salemstate.edu, is an assistant professor at the School of Education at Salem State University in Massachusetts, where he teaches courses in sheltering academic content for English learners (ELs). **ELENA ROSE,** murray.elena@gmail.com, teaches sheltered mathematics for ELs at Revere High School in Revere, Massachusetts. **TONY KING,** tking@bostonpublicschools.org, is the headmaster of Boston International Newcomers Academy, the only public high school in Boston that serves an exclusively EL and former EL population.